



# RESEARCH FOUNDATION

## RESEARCH FOR THE NFPA MISSION

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### Protection of Storage Under Sloped Ceilings – Phase 1

#### Executive Summary

22 February 2016

There is limited prior research and resources to refer to when it comes to the protection of storage under ceilings with slopes steeper than 2/12. Sloped ceilings have the potential to influence the activation pattern of sprinklers relative to the fire source location as well as the optimal design of sprinkler installation for the storage. The dependency on multiple parameters like ceiling slope, stored commodity, sprinkler types, sprinkler orientation, and sprinkler spacing makes this a challenging parametric study. This forms the motivation for the current project initiated by Fire Protection Research Foundation (FPRF), which is to determine the impact of sloped ceilings on the protection of storage and develop the technical basis for the NFPA 13 Technical Committees for new requirements and guidance.

As the first phase of this project, the current report focuses on the objective to develop a test plan (for future work) based on the review of current range of typical storage configurations by Custom Spray Solutions (CSS) and numerical modeling of the principal effects of ceiling slope on suppression performance by FM Global. The research plan was developed through identifying topics in terms of protection design parameters that address knowledge gaps and questions raised from the synthesized configuration and simulation study findings. The numerical modeling study was simulated using Computational Fluid Dynamics (CFD) code FireFOAM. This was broadly divided into two parts a) sprinkler activation study and b) sprinkler sprays investigation. The specific objectives of numerical modeling were:

- To evaluate the sprinkler activation times and patterns from ceiling jet simulations under ceilings having a range of slopes, with large-scale growing fire as plume sources;
- To evaluate the effect of ceiling inclination on water mass flux distributions over rack storage commodity;
- To understand the effect of sprinkler orientation by performing spray simulations with two sprinkler orientations – deflector parallel to the ceiling or to the floor.

This numerical simulation focused research will be used to establish a focused full-scale test matrix for fire testing that will inform NFPA 13 Technical Committee decisions on specific design guidance for sloped ceiling protection.

The following research plan recommendations were presented for a subsequent Foundation study focused on sloped ceiling storage protection:

- To focus on topics addressing protection design questions related to ceiling configuration and sprinkler installation design elements, most importantly those associated with sprinkler orientation, ceiling dimensions (e.g. slopes), and ceiling construction details (e.g. ridges and purlins).
- To perform suppression focused fire simulations utilizing industry leading best practices (e.g. sprinkler initialization by laboratory spray measurements and FireFOAM fire simulation software) and addressing focus topics previously mentioned;
- To formulate a full-scale test matrix for the next phase to provide specific actionable guidance to the NFPA 13 Technical Committee for sloped ceiling storage protection.